A Review of Diagnostic Techniques for ISHM Applications

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Ann Patterson-Hine (NASA ARC)

Gordon Aaseng (Honeywell)
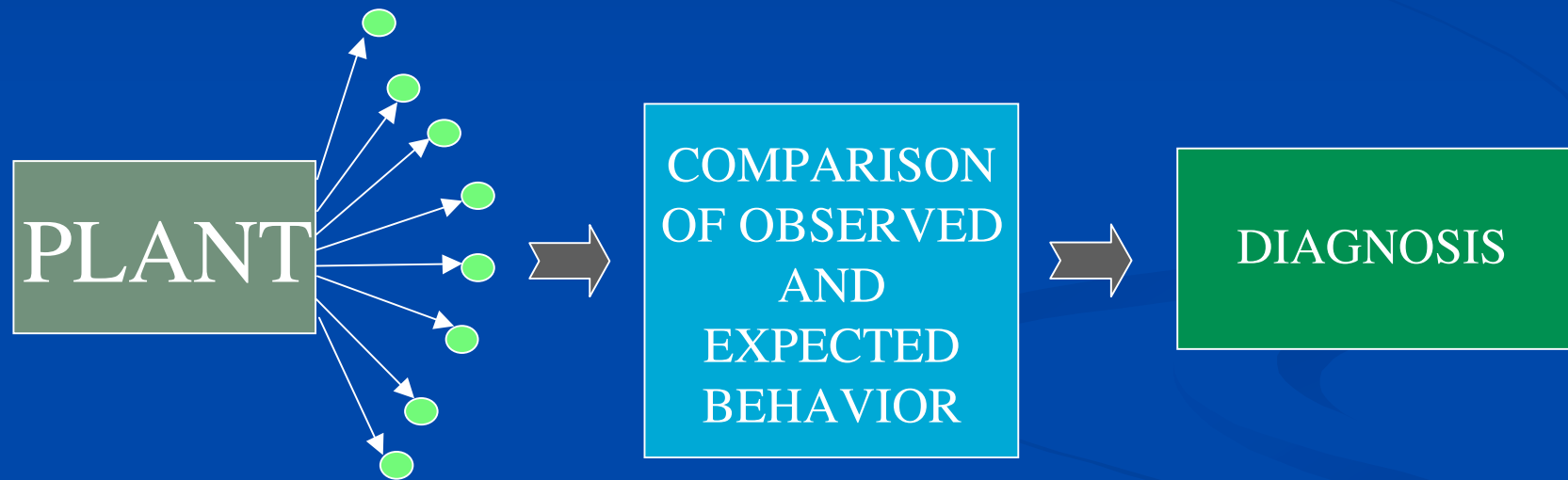
Gautam Biswas (Vanderbilt)

Sriram Narasimham (UCSC/NASA ARC)

Krishna Pattipati (Univ. of Connecticut)

A General Process for Diagnosis

OBSERVATIONS (*may be direct or inferred*)

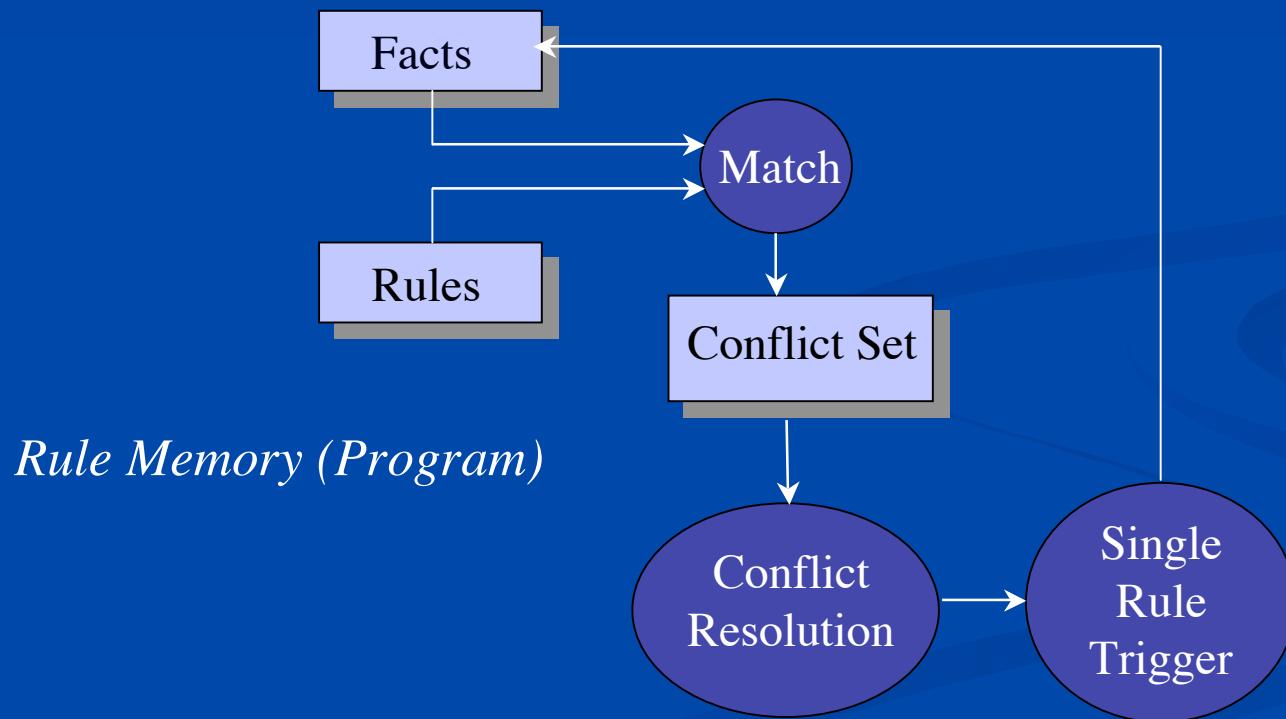PLANT → COMPARISON OF OBSERVED AND EXPECTED BEHAVIOR → DIAGNOSIS

Diagnosis is the process of determining the cause of any abnormal or unexpected behavior.

Diagnostic Techniques Overview

- Rule-based expert systems
- Case-based reasoning systems
- Model-based reasoning systems
- Learning systems

Rule-based Expert Systems

Working Memory (Data)

Rule Memory (Program)

Facts

Rules

Match

Conflict Set

Conflict Resolution
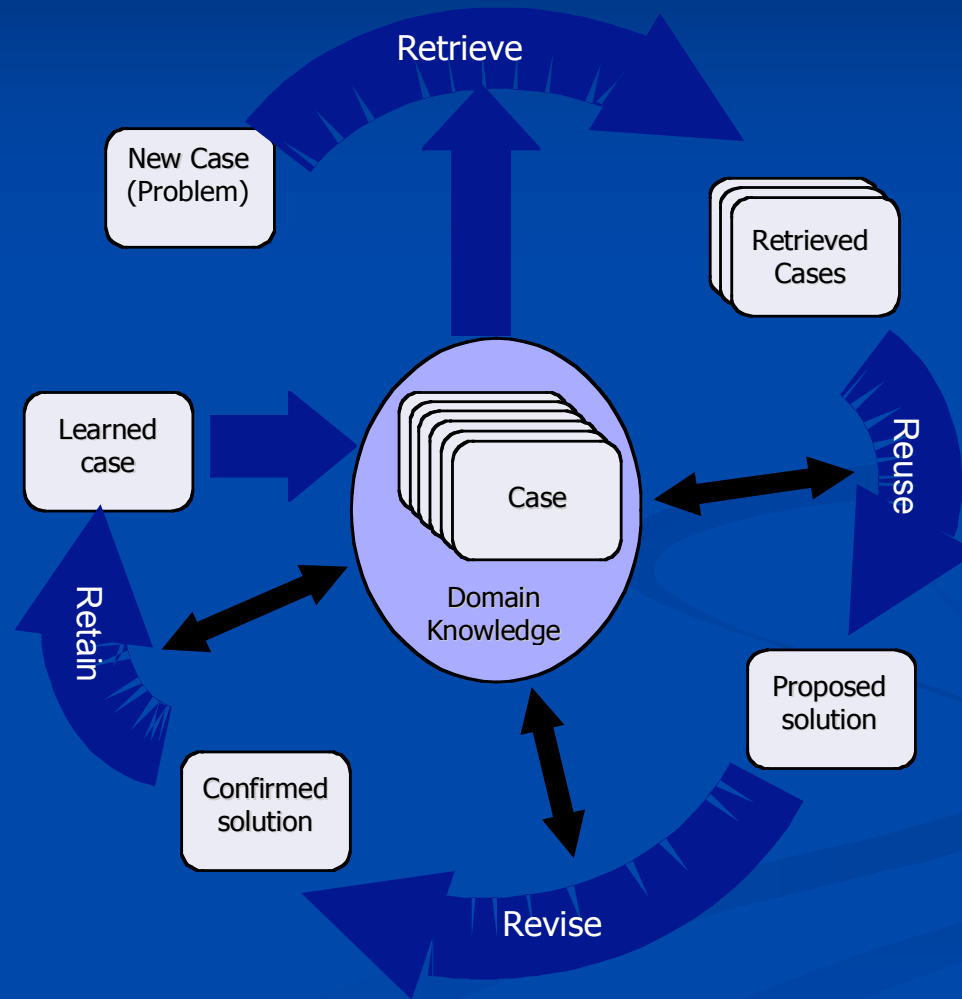
Single Rule Trigger

Rule-based Expert Systems

- Advantages
  - Increased availability and reusability of expertise at reduced cost
  - Fast, consistent response
  - Increased safety
- Challenges
  - Domain knowledge acquisition
  - Resolving conflicts
  - Completeness of rule base
  - Maintenance of rule base
  - Scalability

Case-based Reasoning Systems
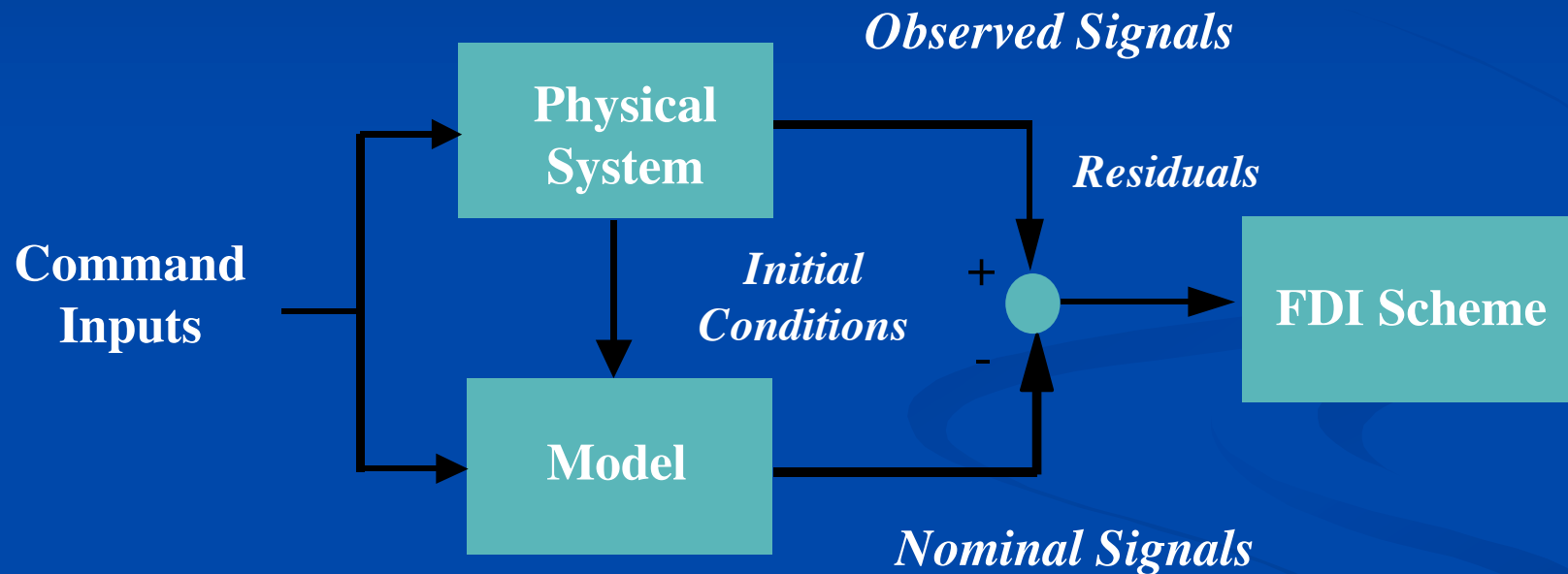
Case-based Reasoning Systems

- Advantages
  - Increased availability and reusability of expertise at reduced cost
  - Fast, consistent response
  - Increased safety
  - Learning component enables adaptation to similar situations
  - Works well in conjunction with a human operator (system can make suggestions in unusual situations)
- Challenges
  - Domain knowledge acquisition
  - Indexing and retrieving case information
  - Completeness of case base
  - Maintenance of case base

Model-based Reasoning Systems
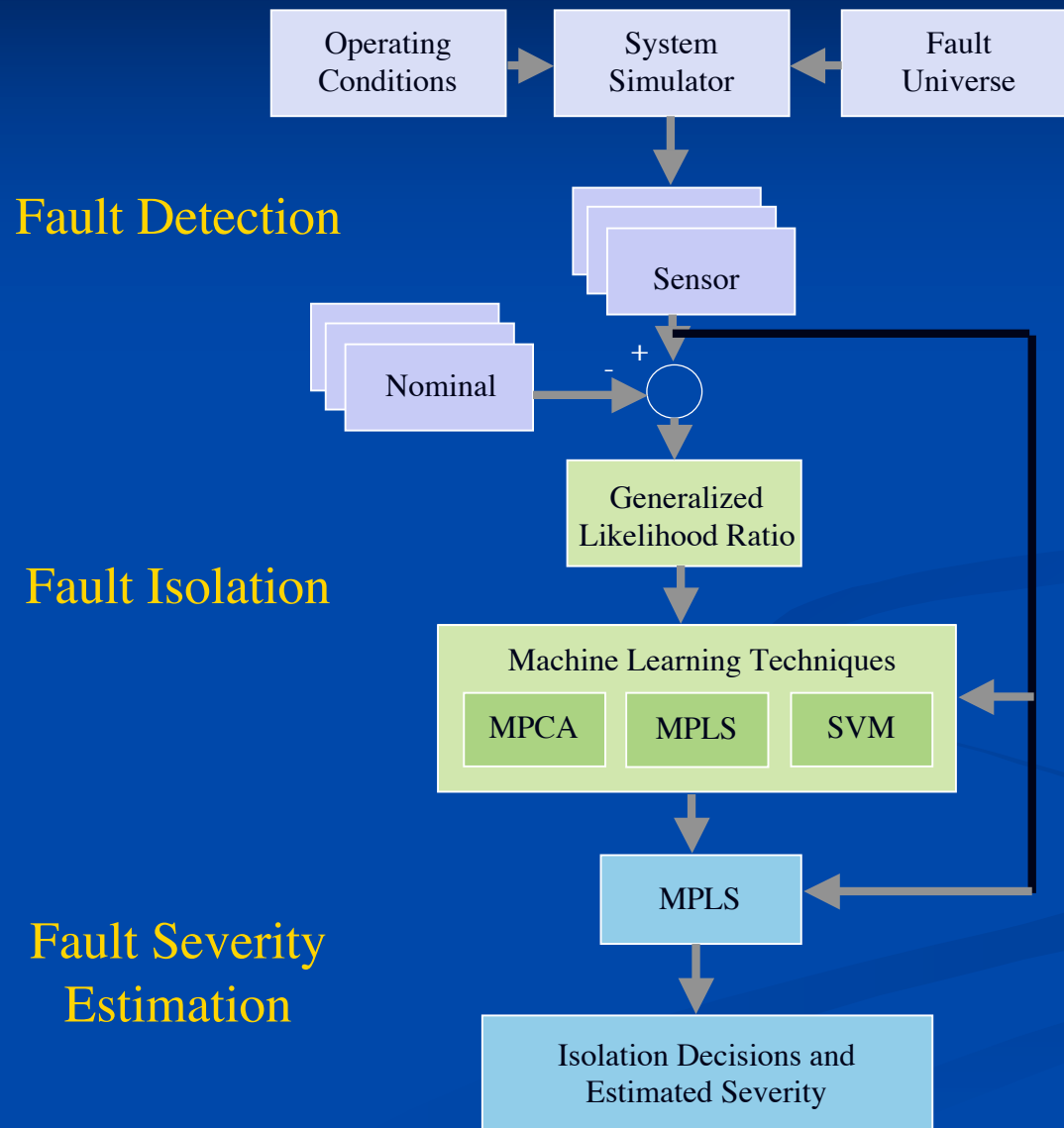
Model-based Reasoning Systems

- Advantages
  - Engineering models form basis for diagnosis
  - Interrogation of fault propagation graphs is very efficient
  - Hybrid approaches use a combination of techniques
  - Flexible
- Challenges
  - Model building and validation
  - Scalability
  - Flexible

Learning Systems

Learning Systems

- Advantages
  - Data-driven approaches are able to transform high-dimensional *noisy data* into lower dimensional *information*
  - Provide monitoring capability
  - Facilitate model-building via identification of dynamic relationships among data elements
- Challenges
  - Highly dependent on quantity and quality of system operational data

Human-System Considerations

- The decision to automate a diagnostic function should be made because the automated system:
  - Can provide valuable information that otherwise could not be obtained at all or obtained quickly enough to be useful
  - Offers significant improvements in the quality of information over human-performed diagnostic activities
  - Can perform the diagnostic function at a lower cost than human-performed diagnosis
- Diagnostics designed to improve safety and mission assurance should be able to demonstrate the degree of improvements provided.

Automation Decision-Making